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ABSTRACT

The first phase of the study described was designed in 1986 to investigate why some high-ability minority students follow through with their plans to enroll in college and major in mathematics, science, or engineering (MSE) fields, while others do not. An initial study was succeeded by a first follow-up in 1987, which indicated that minority students persisted in MSE fields to an unusually high degree. A second follow-up was planned and conducted in the 1989-90 academic year through telephone interviews of respondents to the first follow-up questionnaire. The working sample consisted of 5,531 students of American Indian, Black, Mexican American, Puerto Rican, White, and Asian American ethnicity. Results continued to affirm that minority students persisted in MSE fields to an unusually high degree. Persisters were distinguished chiefly by course-selection patterns in high school and college and their personal commitment to MSE. Ethnicity per se contributed little to the prediction of MSE persistence. An appendix describes the telephone tracking procedure. (Contains 1 figure, 22 tables, and 14 references.) (SLD)

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PERSISTENCE IN SCIENCE OF HIGH-ABILITY MINORITY STUDENTS, PHASE IV: SECOND FOLLOW-UP

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Princeton, New Jersey
October 1995

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PERSISTENCE IN SCIENCE OF HIGH-ABILITY MINORITY STUDENTS, PHASE IV:

SECOND FOLLOW-UP

The final report of a project supported by the National Science Foundation,
Grant No. MDR-8955092

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To the list of individuals whose contribution was acknowledged in the report on the first follow-up, we must add María Pennock-Román whose extraordinarily thorough review of the present report was invaluable. We regret that time and budget limitations prevented us from implementing all her suggestions. Those we did implement greatly improved the report.

The first author is also grateful to his colleague Jerilee Grandy with whom many profitable discussions have been held. Grandy is conducting a final phase of this line of research.

Ruth Yoder typed the final revision of this report. Our thanks to her.

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FINAL REPORT

Persistence in Science of High-Ability Minority Students, Phase IV:

Second Follow-Up

Overview

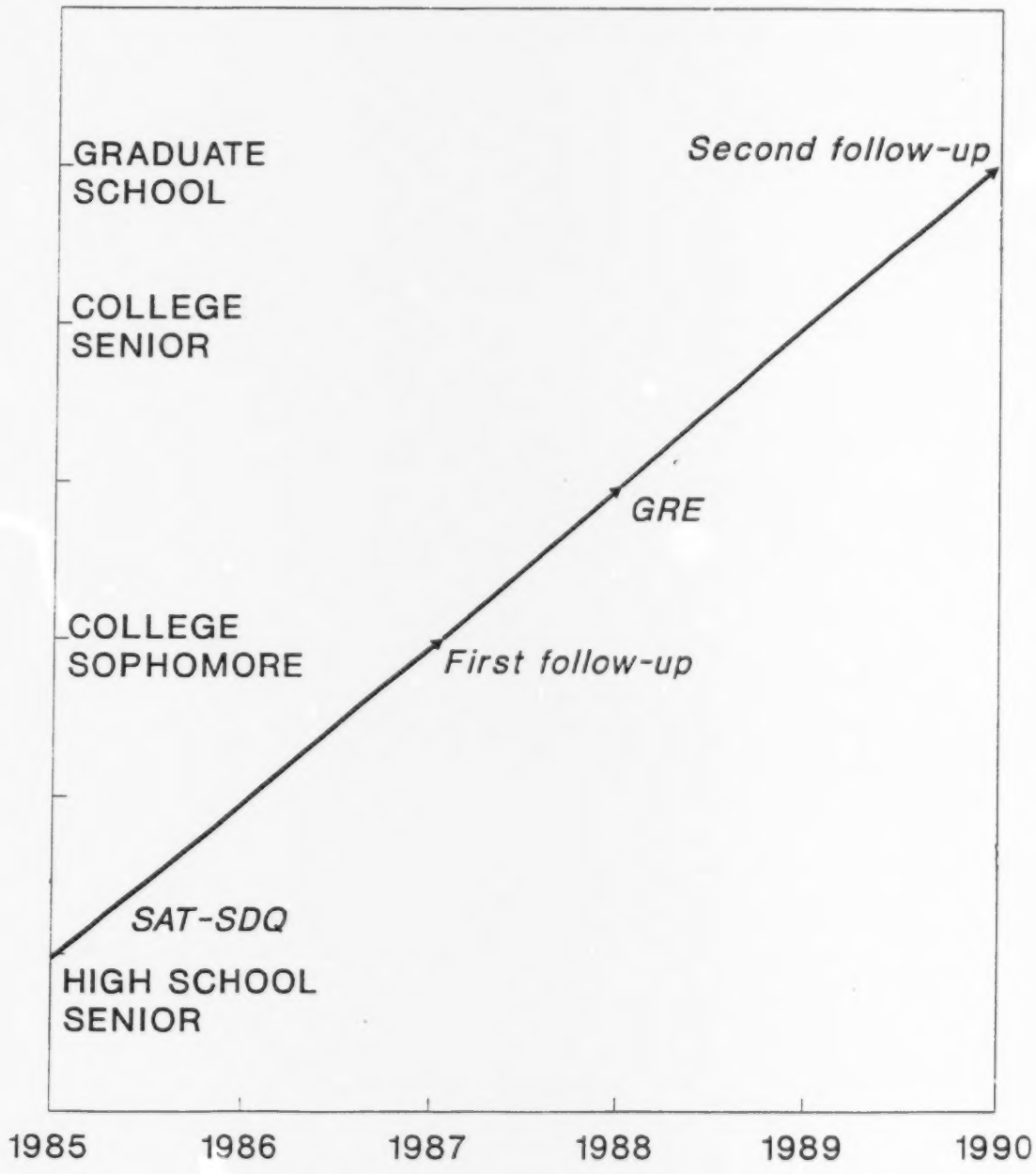
In view of the critical national importance of increasing the number of minority students, especially those of high ability, in math, science and engineering (MSE) fields, the first phase of this study was designed in 1986 to investigate why some high-ability minority students follow through with their plans to enroll in college and major in MSE fields while others with the same plans do not. The study was requested by NSF's Committee on Equal Opportunities in Science and Engineering. High ability was defined as achieving a score of 550 or above on the SAT mathematical. Planning MSE majors was defined in terms of appropriate items in the Student Descriptive Questionnaire (SDQ) which is completed by most students who take the SAT.

Initial sample. A sample of 354 American Indian, 2,666 Black, 1,488 Mexican American and 690 Puerto Rican students who took the SAT in 1985 were studied. In addition, 404 White students who met the same criteria were selected at random for comparison purposes and also 688 qualifying Asian American students were selected for a special study that is described in a supplementary report.

First follow-up. As shown in Figure 1, a two-year follow-up was conducted in 1987 as part of Phase I. This indicated that the minority students persisted in MSE fields to an unusually high degree. Sixty-one percent had enrolled in college and were actually majoring in an MSE field or intended to do so. (In comparison 55 percent of the White students persisted and 70 percent of the Asian American students.) The largest number who withdrew from MSE majors transferred to non-MSE majors. Only a minute percentage (.3 percent) were dropouts in the usual sense of the word.

Figure 1

Data Collection Plan



The persisting students had higher mean SAT math scores but lower SAT-verbal scores than the students who transferred to other majors.

Best predictor. The nature of the college environment, including recruitment and retention efforts and the perceived quality of MSE instructional programs, was the most important predictor of persistence. Ethnicity per se contributed not at all to the prediction when a number of other variables were, in effect, held constant. The results indicated that when minority students have the opportunity to acquire the skills and interest required for successful study in MSE fields, they persist to a degree that is as high if not higher than that of White students.

Need for second follow-Up. The first follow-up of the sample served very well to identify the personal characteristics, the high school experiences and the early college experiences of the students who persisted in their plans in contrast to several categories of sample members who did not. Of equal or more interest, however, are the number and characteristics of students who persist in undergraduate schools until award of the baccalaureate degree in MSE fields and, further, either continue MSE study in graduate school or take positions in an MSE field. Accordingly, a second follow-up of the original sample was proposed, and was conducted in the 1989-1990 academic year, five years after the sample members took the SAT as high school seniors.

Status survey. The major data collection was a telephone interview which was held with all sample members who responded to the first follow-up questionnaire. Short questionnaires were mailed to the balance of the original sample. These procedures provided data on the current educational and occupational status of the original sample and permitted a detailed description of the personal characteristics and experiences of the persisters and the non-persisters. These results are of substantial national interest in regard to the future supply of high-ability minority students in MSE fields.

Case studies. As a source of hypotheses, twenty in-depth case studies were conducted. Factors that were found to be related to persistence were incorporated into a conceptual model of the persistence process.

Related Research

As described in the original proposal and in the report on Phase I, a copy of which accompanies this report, a large number of studies have investigated why students leave college majors or college altogether. Some have focussed on minority students but none of the studies that we examined focussed on high-ability minority students in math, science, engineering, premedical and predental fields.[1] The general literature was informative, nonetheless, and is summarized in detail in the attached report. The final conclusion of the review was as follows:

Clearly, there is no single reason for withdrawal from MSE majors, or even a small set of reasons. Which psychological model to adopt to guide the data collection and analysis is a difficult and important question. After considering a number of models, most of which are summarized in an excellent manuscript by Tinto (1987), we have tentatively adopted what might be called a psychoeconomic model, an eclectic approach reflecting Murray's early theory of personality (1938), Simon's behavioral model of rational choice (1955), Hilton's theory of career decision-making (1962), and Tinto's theory of student departure (1987). In brief, we view students as choosing to attend college and to major in a certain field because they perceive the chosen field as most likely--relative to alternatives--to satisfy what they perceive as their present and future psychological and physical needs. These needs include the need for achievement--through academic grades and awards and, for some, athletic accomplishment; the need for affiliation--through friendships, clubs, teams, and living facilities; and the need for

[1]As explained in the original proposal, premedical and predental students were added to the sample at the request of the Committee on Equal Opportunities in Science and Engineering.

understanding--through classroom and laboratory work and home study. Other needs could be mentioned; Murray lists twenty in the work cited.

Abilities are important in the model, for they influence the probability of needs satisfaction. Thus, high mathematical or quantitative ability increases the chances of an individual's gaining an understanding of math, science, or engineering. Social ability (defined by Murray as "the ability to make friends easily, to 'get on' with people, to be liked and trusted," op. cit., p. 229) will increase the probability of a student's achieving the kind of social integration that Tinto emphasizes.

The third class of variables concerns the nature of the students' environment or what Murray referred to as "environmental press." Whether the faculty of a particular department is accessible, sociable, and concerned about the well-being of its students must have an important effect on student persistence in that department.

Assuming that these three categories of variables include the bulk of those variables that influence attrition, how do we treat measures of the variables so as to predict the probability of a student's withdrawal from a MSE major? As a first cut at the problem, we proposed that a student withdraws from a program when the net satisfaction anticipated from participation in the program during the next period is less--by some degree--than the net satisfaction of some alternative course of action perceived by the student, e.g., transferring to another department.

The report of Phase I then went on to discuss some of the terms used in this conclusion. The model continued to guide the instrument development and data analysis of the work described here. As is mentioned later in this report we found the results of the data analysis to be consistent with the model.

Objectives

The primary objectives of this second follow-up were as follows:

1. To document, five years after high school graduation, the educational and occupational status of each member of the original sample.
2. To examine how persistence in MSE fields varies across major subgroups of the sample,
3. To investigate the personal, experiential and situational correlates of persistence in MSE fields,
4. To refine a theoretical model of the persistence process and,
5. To recommend steps that NSF and educational institutions in the United States can take to increase the number of minority students who complete their education in MSE and medical fields.

Specific Questions

To what extent high-ability minority students persist in their career plans in the MSE field is an important question in itself. We know from the first follow-up that a high proportion persist through the first 1-1/2 years of undergraduate school. But the answers to the following questions were not known:

1. What proportion continue their MSE study and, within five years, either receive a bachelor's degree or definitely expect to do so? Of particular interest will be those who were enrolled in two-year or junior colleges. The two-year to four-year college transition is well known to be a difficult hurdle for many students, especially Hispanic students (Astin, 1982; Hilton & Schrader, 1987; Olivas, 1986).
2. Of those who receive BS degrees, what proportion enroll in graduate study in MSE fields (or have definite plans to do so) and what proportion accept employment in

MSE positions? Of special interest will be the proportion who left MSE fields to enroll in the study of law, business administration and teaching. Has there been an undue loss to these fields from MSE fields? What are the characteristics of students who make the change?

3. What proportion of the sample members who in the first follow-up were classified as non-persisters (dropouts, stopouts, transfers, etc.) actually returned to MSE study? Analysis of High School and Beyond data indicates that the proportion returning to MSE study is larger than expected (see Solorzano chapter in Hilton, et al., 1988) but whether this is true for high-ability minority students is unknown.
4. What are the national policy implications of the results that will be obtained? At what educational level is investment likely to have the highest pay off? What form should expenditures take? Financial awards? Information dissemination? Educational programs? For students? Or teachers? Or institutions?
5. For each of the preceding questions, are there differences between ethnic groups and between genders? Gender differences within ethnic groups were of particular interest but there were not sufficient cases for certain comparisons of interest even though we started with 5,000 cases. For example, the number of American Indian women responding to the first follow-up was 47, meaning that the number in several follow-up categories of interest was less than 10.

Design Considerations

Guiding the planning of the data collection were a number of considerations that have grown out of the principal investigator's experience in the last thirty years in conducting studies of student development and, especially, career decision making, school leaving and persistence (Hilton, 1960, 1962, 1979, 1982). Among these considerations is the conviction that the reasons

individuals give after the fact for leaving a particular major or a school tend to be rationalizations for their actions and not necessarily related to the facts of the matter. For example, a student who withdraws in the middle of a semester because he is failing academically may later report that he withdrew because the school did not have adequate laboratory facilities. Or a student who discovers she has chosen a major in which she has no real interest may report that she withdrew for financial reasons. Or the student who withdraws for reasons unknown to him other than that he became bored and dissatisfied may agree with any plausible reasons which a multiple choice item offers him.

Assuming that the foregoing consideration was valid, what was its implications? The first was that little would be gained by presenting students who had left a major or a field with a list of possible reasons for doing so and asking them to check those that were applicable. Even open-ended items which are coded later are likely to yield much rationalization and fabrication.

The second implication was that longitudinal designs in which students are surveyed well before they withdraw would yield more valid data. This was the case in the present study. We had the unusual opportunity of relating student self-report data obtained five and three years earlier with current status data.

The third implication was that interview schedules and questionnaires should, insofar as possible, stick to verifiable objective facts, such as number of semester hours taken in a particular subject, whether enrolled in a two-year or a four-year college, and grade point average.

The fourth implication was that if one is searching for "real" reasons for leaving school, the best data are derived from in-depth interviews. In such interviews, superficial responses can be probed, clarifying questions can be asked, possibly spurious relationships can be examined, and enough information can be obtained to reveal inconsistencies and rationalizations. Also the

interviewer has time to establish rapport with the sample member and to demonstrate sincere interest and concern for valid responses.

The second design consideration concerned hypothesis testing. Although we regard case studies as a rich and productive source of hypotheses about the process of persistence and, conversely, school leaving, it is still necessary to conduct additional data collection with a suitably large sample to test the generality of whatever propositions are derived from the case studies.

General Plan of Work

Sample

The sample was the same as that of Phase I, namely, all SAT takers in 1985 who met the following criteria:

1. They scored 550 or higher on the SAT mathematical test;
2. They indicated in responding to the Student Descriptive Questionnaire (SDQ) that their first choice of college major was either mathematics, natural or physical science, engineering or a premedical or predental program. As shown in the appendix of the report on the first follow-up (Available from ETS as RR-89-23), majors in biology, medical sciences, agriculture, architecture, predentistry and premedicine were included in the MSE category but majors in psychology, sociology, linguistics and other social sciences were excluded. The first author's frequent research observation is that high school and college students usually view the social sciences, especially psychology, as a way of avoiding science and mathematics.
3. They identified themselves as a member of one of four ethnic groups: American Indian, Black, Mexican American or Puerto Rican.

In addition, a random sample of 688 Asian American and 404 White students who met the same criteria was drawn for comparison purposes. These steps yielded the following initial sample after elimination of 251 noncitizens:

American Indian	354
Black	2,666
Mexican American	1,488
Puerto Rican	690
Asian American	688
White	404
Total	6,290

After elimination of 16 duplicate names, and 247 sample members with foreign addresses, 6,027 remained. In Phase I, first-class letters were sent to the home addresses of these sample members. Of these, 496 were returned as undeliverable, without known changes of address, leaving a base sample of 5,531. This was the working sample for the second follow-up.

Data Collection

Status survey. In order to have up-to-date information on the educational and occupational status of the sample, data on the sample's future plans and certain critical demographic data, a 15-minute telephone interview was held with about three-fifths of the sample and the balance was surveyed by mail. (The explanation for this procedure follows shortly.) Table 1 summarizes the topics which were covered. The telephone interviews were conducted by the Public Opinion Laboratory at Northern Illinois University under the direction of Jon D. Miller and the day-to-day management of Man Tsun Cheng.

The telephone sample members were those members who, in responding to the first follow-up questionnaire, replied to the following item:

Thank you very much for your cooperation. We would appreciate information that can help us stay in contact with you. Please print your name, address, and telephone numbers where you can be reached during the next year or two:

Your name: _____

Spouse's name, if married: _____

Street address: _____

Telephone number: Area Code(_____)_____

City: _____

State: _____ Zip _____

Please print the name, address, and telephone number of your parent(s), another relative, or a close friend who will know where to get in touch with you during the coming year

Name: _____

Relationship to you: _____

Street address: _____

Telephone number: Area Code(_____)_____

City: _____

State: _____ Zip _____

The College Board, which requires that the permission of SAT takers be obtained before they are called for telephone interviews, agreed that the sample members who responded to this item tacitly consented to our calling them. Approximately 3,000 sample members did so and these were called. The balance received a brief mailed questionnaire embodying the critical items of the telephone interview. Copies of the full telephone interview schedule and the short questionnaire may be obtained from T. L. Hilton.

Pilot study. In order to be sure that enough sample members could be reached and interviewed by telephone at a reasonable cost, a pilot study of the telephone interview procedure was conducted by the Public Opinion Laboratory at Northern Illinois University. A spaced sample of 100 cases was drawn from the respondents to the first follow-up questionnaire and their questionnaires were sent to the Public Opinion Laboratory where highly trained and experienced operators called each sample member, following an interview schedule which covered the items shown in Table 1.

Table 1

List of Topics Covered in Status Survey

Current enrollment or past enrollment
Level
Degree being sought
Major field of study
Cumulative grade point average
Grade scale
Math and science grades relative to other grades
Full or part time
Quarter or semester system
Number of courses per quarter or semester
Name of school
City and state
Whether BS received
Future educational plans
Whether GRE taken
Level of future study and degree expected
What might change plans
Means of support
Current employment (if any)
Hours each week
One job or more
Primary occupation
Relation to major field
Job title
Temporary or career
If no current work whether work expected
Occupation expected at age 30
Number of dependents
Financial assistance from school and relatives
Marital status
Whether spouse works and, if so, type
Whether spouse attends school
Number of children
Children expected
Whether willing to participate in longer interview, phone number, and verification of address

Some sample members were reached on the first call, others required many calls, giving an average of three calls per sample member. Most of the sample members were not at the first number that was called. Considerable ingenuity was required to reach some sample members. Laboratory staff reported that once sample members were reached, they were cooperative, even eager, to report on their status. No monetary incentive was offered. Eighty five percent of the pilot sample was successfully interviewed. An additional sample member who did not wish to be interviewed by telephone did agree to respond to a written questionnaire. Two other sample members were reported to be overseas. Questionnaires were mailed to these last two categories.

Examination of the summary tabulations of the interviews--a valuable by-product of the computerized telephone interviewing technique--indicates that item response rates were unusually high, being 100 percent for most items.

Based on the pilot study conducted by Public Opinion Laboratory, the cost of a telephone interview was $38 per respondent, not including management expenses.

In comparison, the mail survey conducted by ETS as part of the first follow-up yielded an 82 percent response rate (after nondeliverable cases were excluded) and cost approximately $63 per respondent, excluding management costs. Much of the difference in cost between the phone survey and the mail survey was due to differences in cost rates of the two organizations. Comparison of the item-by-item tabulations from the telephone survey with the tabulations for the mail survey indicated that the mail survey items had a substantially higher item nonresponse rate. Apparently the personal contact between the telephone operator and the respondent greatly reduces item nonresponse.

Thus, for our purposes, the telephone interview showed promise of providing superior results at less cost even though the pilot study was conducted four years after high school graduation and the first follow-up was conducted two years after. On these grounds, we decided

to give priority to the telephone survey. The goal of the Public Opinion Laboratory was to achieve a 90 percent response rate which, as will be shown shortly, was achieved.[2]

Case studies. Case studies were designed to lend texture and richness to the more objective data obtained in the telephone status survey and also to help explain the correlations that were generated in the analysis of the survey data. Each of the 20 subjects who were interviewed was paid $10. The interviews averaged about forty minutes in length. The interviewers reviewed everything known about the sample members before starting the interview. All of the interviews were by telephone. Half were conducted by the principal investigator and the balance by Jayjia Hsia and Linda Jung. Ms. Jung contributed substantially to the development of the interview protocols.

Sample questions. The goal of the interview was to obtain a valid description of the sample member's development in the five years from taking the SAT to the second follow-up, including the apparent reasons for each change in status and plans, recognizing that for some changes there were no apparent reason. The following are some sample questions:

- What would you have done if your grade point average had been higher?
- What might have happened that would have made it possible for you to continue?
- What other factors may have contributed to your decision to transfer (we tried not to accept a single reason for a decision)?
- How would you compare the social life at the two schools (for those who may have transferred to a different field at a different school)?
- How would you compare the educational climate of the two departments?
- How did you feel about the faculty of the engineering department?
- If money had been no problem whatsoever, would you have continued in your major?

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[2] A copy of the telephone interview protocol used by the Public Opinion Laboratory may be obtained from T. L. Hilton (See the AERA directory for current address).

- (For married students) How did your husband (or wife) feel about your decision?
- What are the chances of your returning to the MSE field for graduate school?
- Under what circumstances would you return to an MSE major?
- Our records indicate you are Black (Puerto Rican, Mexican American, Asian American, or Indian). Have you experienced discrimination?
- What form did this discrimination take?
- In a typical classroom how many others like you would there be?
- How do your parents feel about the decision you made to (describe fairly specifically the decision in question)?
- How do your friends feel about this decision?
- Do they think it was a good decision for you to make? (If appropriate) What would they have liked to see you do?
- What reason do they have for this idea?
- We all take steps for reasons that we don't really understand. Considering obvious reasons (if appropriate) and less obvious reasons, why do you think you took this step?

Response Rate

Table 2a summarizes the response rates for the total study beginning with the original sample. If we define the population of interest as SAT-takers of U.S. citizenry living in the United States with a known address, the response rate for the total data collection was 69 percent, which we regard as marginally acceptable. Examination of the SAT scores and demographic characteristics of the non-respondents indicated that they had lower scores and less educated parents than the respondents, as usually is the case in such surveys. The reader is also reminded that sample members had to have SAT-math scores of at least 550 and show an interest in MSE majors. Thus the responding sample is not a random sample of college students; rather it is a highly selected sample.

Table 2a

Response Rates

Original sample		6,541
Less:		
Non-citizens	251	
Foreign addresses	247	
Duplicates	16	
Balance		6,027
Less undeliverables (no known address)	496	
Balance		5,531
First follow-up		
Completed Postsecondary Experience Survey (PES) (55% of 6,027, 60% of 5,531)	3,334	
Parents returned postcard (18% of 6,027, 19% of 5,531)	1,069	
Total participation (73% of 6,027, 80% of 5,531)		4,403
Second follow-up		
Telephone survey		
Maximum eligible	3,334	
Less:		
Hold-out sample	110	
Out-of-country	41	
Balance eligible	3,183	
Interviewed by telephone (90% of 3,183)	2,870	
Short questionnaire		
Number mailed	2,887	
Less undeliverables	688	
Balance	2,199	
Questionnaires returned (33% of 2,887, 43% of 2,199)	948	
Participants in case studies	22	
Total participation (64% of 6,027, 69% of 5,531)		3,840

Data Analysis

Status Survey

The status data from the second follow-up was merged into the project file and was analyzed with two objectives:

1. To obtain a broad range of descriptive results for general information and program planning purposes, and
2. To obtain predictive equations, for the same purposes.

In the descriptive analyses, the sample was first divided into criterion groups which will be described shortly. Scaling of the criterion groups provided a dependent variable for multiple regression analyses.

Case Studies

No data analysis of the case studies was conducted although we did code the contents of each interview into categories and tabulate the results in a way that permitted us to detect recurring themes and uniformities across subjects. If, for example, most of the persisters cited the same particularly favorable experience and none or few of the non-persisters did, then we regarded that experience as possibly significant and as suggestive of a variable that should be incorporated into the conceptual model of persistence that was the principal product of the case study phase.

In conducting the case studies we were guided by the work of Stake (1981), Guba (1978) and Patton (1980), a former associate of the principal investigator.

Development of Criterion of Persistence

Requirements. The first and probably most critical part of the data analysis was to develop a criterion of persistence in science and engineering. There were several requirements

for this criterion: First, with several thousand subjects it was important that it be scorable. Second, it was important that it take into consideration the many possible outcomes. As it turned out, when we put together all possible combinations of educational attainment on full- or part-time work, there were a total of 220 possible outcome categories.

Third, it was important that the outcome categories provide for distinctions among sample subjects that our theorizing about persistence suggested were important. For example, it was important to us to be able to distinguish between sample members who left math, science and engineering because they transferred to another major which presumably was more attractive to them and sample members who left math, science and engineering and never continued their education within another major.

Fourth, the outcome categories had to be sufficiently unambiguous to enable us to assign the category a criterion score in a defensible and reliable way.

Actual steps. With the results of the first follow-up, conducted two years after high school graduation, we were able only to categorize the sample into three large groups: persisters (still in college and majoring in MSE fields or intending to do so), transfers (in college but majoring in a non-MSE field), and others. A scale of persistence reflecting possible degrees of persistence was out of the question. The results of the second follow-up did, however, introduce the possibility of a scale, specifically, a six-point scale from "no evidence of interest" (0) to "Full Persistence" (5). How this was developed is described in the following paragraphs.

The first step was to identify the possible outcome categories. We were limited in degree of specificity because we had only a brief status questionnaire for approximately 1000 sample members. Consequently the outcome categories were limited to combinations of college, graduate school, and work status as shown in Table 2b.

The next step was to reject those combinations of outcome categories which were impossible or highly unlikely (e.g., full-time college MSE, full-time graduate school MSE, and

full-time work). Then the remaining combinations were assigned to a criterion score group, solely on a priori grounds.

Table 2b

Major Outcome Categories

College	Grad School	Work
a. Never	a. Never or omitted	a. Not or Omitted
b. MSE full time, left	b. Full time, MSE	b. Part time
b. non-MSE full time, left	b. Full time, non-MSE	c. Full-time non-MSE
c. MSE part time, left	c. Part time, MSE	d. Full-time MSE
c. non-MSE part time, left	c. Part time, non-MSE	
d. MSE full time, now		
d. non-MSE full time, now		
e. MSE part time, now		
e. non-MSE part time, now		
f. MSE, B.S.		
f. non-MSE, B.A.		

The resulting outcome groups and the scoring category to which they were assigned are shown in Table 3. The first group, which was assigned a score of zero, included two subgroups, the first of which comprised sample members who never enrolled in undergraduate school as MSE majors, either full time or part time. The second subgroup comprised sample members who did enroll in undergraduate school but not in MSE majors either full time or part time, and any work they may have been engaged in either full time or part time was not related to the MSE field. Thus, in general, the five criterion subgroups assigned to this score category never displayed any evidence of interest in math, science and engineering work or study. This raises the question of why they indicated in taking the SDQ that they intended to enroll in college and major in an MSE field. The answer probably reflects the difference between the tentativeness of planning late in high school and the reality of commitments in the sophomore year of college.

Table 3

Criterion Groups

Score	
5	Full persistence BS, full-time MSE work Full-time MSE graduate school, regardless of BS BS, part-time MSE graduate school
4	BS but less than full commitment BS, no graduate school and non-MSE work BS, non-MSE graduate school
3	Majoring in MSE now Majoring in MSE now MSE part time now, MSE work
2	Left MSE but definite interest in MSE MSE full or part time, left, MSE work full time Non-MSE BA, MSE work full time Etc.
1	Some evidence of current MSE interest Never in college but full-time MSE work Non-MSE work, MSE study part time Etc.
0	No evidence of current interest Never enrolled in MSE study full or part time Non-MSE study full or part time and left and not in MSE work

The second level of persistence, assigned a score of 1, were those who showed some evidence of current or past interest in the MSE field. For example, the members of one subgroup never enrolled in college but they reported they were engaged in what was classified as full-time MSE work, such as that of electrician, electronic technician, or computer operator. Another subgroup were engaged in non-MSE work but were studying in an MSE field part time.

As can be seen from the table, persistence increased to level 5 for "full persistence." This scoring category included three subgroups: (1) those who received a bachelor's degree in

math, science or engineering (or premedical or predental fields)[3] and were engaged in full-time MSE work, (2) those enrolled full time in an MSE graduate school (regardless of what their undergraduate schooling may have been) and (3) those with a bachelor's degree in an MSE field who were enrolled part-time in an MSE graduate school.

Thirty-nine cases that could not be assigned to one of the 6 criterion groups were assigned to an "unclassified" category. The number assigned to each group is shown in Table 4.

Table 4

Number and Percentage Assigned to Outcome Category

Score		N	Percent
0	No evidence of interest in MSE	1,259	33
1	Some evidence of interest	350	9
2	Left MSE study but still interested	180	5
3	Majoring in MSE	957	25
4	MSE Bachelor's degree	214	6
5	Graduate work in MSE or BS in MSE and working full time in MSE position	812	22
	TOTAL	3772	100

Relationship to Test Scores

Graduate Record Examination test scores and personal history responses were retrieved for 604 sample members who for their personal educational purposes took the GRE. As partial evidence of the validity of the persistence criterion scale, the mean GRE scores for the members of each of the six criterion groups was computed. Our expectation that the GRE quantitative score would display a monotonic relationship with the persistence scale but that the GRE verbal score would not necessarily do so was borne out to a surprising degree, as shown in Table 5. Without exception the mean quantitative scores increase as the criterion score increases. On

[3]Throughout the results sections of this report the MSE fields include medicine and dentistry unless otherwise noted.

the other hand, the verbal score showed no consistent relationship, perhaps because subjects with high verbal scores tended to migrate to fields placing a premium on verbal skills. The dynamics of the situation are, however, probably complicated. It no doubt is the case that some sample members, on receiving their GRE scores, decided not to pursue further their early interest in MSE fields. Thus, for these subjects, their GRE scores became a self-fulfilling prophesy. Nevertheless, we interpret the strong correlation between the GRE math scores and persistence as substantial evidence of the validity of the constructed criterion scale.

Table 5

Mean GRE Quantitative Score of Six Criterion Groups

	Criterion Group	N	$\bar{X}$
0	No evidence of interest	101	546
1	Some evidence	23	566
2	Left MSE, definite interest	23	595
3	Majoring in MSE	150	609
4	BS degree	69	625
5	Full persistence	238	673
	TOTAL	604	624

In addition, the scale has a correlation with SAT Math of .20, significant at .001 level, despite the fact that the sample was selected on the basis of the Math scores and, thus, the scores are restricted in range. (See Table 6.) As expected, the correlation with SAT verbal (Table 7) is only .05, our hypothesis being that high-verbal subjects are more likely to transfer to non-quantitative fields than low-verbal subjects are.

Many additional correlates of persistence are discussed shortly.

Table 6

Mean SAT-Math Score of Six Criterion Groups

	Criterion Group	N	X
0	No evidence of interest	1,265	605
1	Some evidence	241	605
2	Left MSE, definite interest	288	612
3	Majoring in MSE	666	610
4	BS degree	555	615
5	Full persistence	838	638
	TOTAL	3,853	615

Table 7

Mean SAT-Verbal Score of Six Criterion Groups

	Criterion Group	N	X
0	No evidence of interest	1,265	503
1	Some evidence	241	487
2	Left MSE, definite interest	288	511
3	Majoring in MSE	666	474
4	BS degree	555	500
5	Full persistence	838	523
	TOTAL	3,853	501

Results, Descriptive

Case Studies

Since only 20 case studies were conducted, we can not draw general conclusions from them, but they did serve very well what they were intended to serve, namely, as a source of hypotheses guiding the selection and construction of measures for the data analysis of the full sample. One major conclusion was, however, suggested by the case studies and this is that each individual sample member is indeed unique. There is no single major reason for abandoning a particular career goal. Typically, an individual rejects a career pathway for an array of reasons. Field conditions and how these conditions interact is critical. For example, a student who is

financially destitute and has to work full time in order to exist will persist if his studies are sufficiently satisfying to him and his career goal is sufficiently attractive to him. On the other hand, a less goal-oriented and less satisfied student will not withstand financial deprivation and may in a questionnaire report that he or she abandoned an MSE goal because of financial difficulties. Clearly, it is the balance of positive and negative factors that determine persistence. If we find that a particular factor -- for example, poor instruction -- is a predictor of persistence, it is only because it was common to the arrays of negative and positive factors of enough students for it to emerge from a statistical analysis as a significant factor. Nevertheless, certain factors or themes did emerge from the case studies as possible general factors. These are discussed in the following paragraphs.

Self motivation. Common to nearly all case study subjects who persisted (and consistently lacking in subjects who did not persist) was self motivation. When asked who may have influenced their career choice the most, a high percentage of the persisters reported that they selected their MSE career themselves; that is, that they were self motivated.

Absence of parental pressure. Conversely, a high proportion of the non-persisters mentioned a parent or both parents who were highly influential in their career choice. This seemed to be especially true of students who had started college in premedical or predental programs or who intended to go into such programs. Several of the non-persisters mentioned that they had felt under parental pressure to pursue a particular MSE occupation, whereas none of the persisters mentioned this factor.

Supportive parents. The persisting students did, however, frequently mention how supportive their parents were of the career pathway which they (the students) had selected. Several mentioned the degree to which their parents were sacrificing financially in order to support their educational expenses.

Intact family. Persisters were more likely to mention the presence of both parents in their home, although this factor should not be overemphasized. Among the persisters there were frequent cases of one or both parents not being present in the home for a variety of reasons.

Interested high school science or math teacher. As mentioned above, the persisting students were most likely to name themselves as the person most responsible for their selection of MSE as a career. However, a strong runner-up was high school math or science teachers. Repeatedly in the interviews, the interviewers would mention a math or science teacher who took a special interest in them and encouraged them to take as much math and science in high school as possible. Guidance counselors were seldom mentioned.

Science intervention programs. Frequently in the interviews the students would mention a science intervention program as having influenced their choice of an MSE career. Upward Bound was mentioned by several of the interviewees.

Concerned college faculty. As far as the college years were concerned, interviewees who had rejected MSE careers frequently mentioned disinterest on the part of the faculty of whichever MSE department they had been enrolled in. Conversely, students who persisted in MSE programs frequently mentioned how concerned the faculty of the school had been. There were, of course, exceptions. Some highly motivated interviewees persisted despite what was frequently described as a cold and seemingly disinterested faculty.

Second Follow-Up Status Versus First Follow-Up

Table 8 shows how each category of first follow-up sample members were categorized in the second follow-up; for example, for 142 who were categorized as having rejected careers in math, science, or engineering, there was in the second follow-up no evidence of any persistence in those fields. However, 15 of the first follow-up rejectors showed some continuing interest in

MSE careers, 5 showed definite interest, 56 were actually majoring in MSE, 10 had received bachelor's degrees and 24 displayed full persistence, meaning they were in graduate school pursuing advanced degrees in math, science, or engineering or had bachelor's degrees in these fields and were working in MSE occupations. Obviously, many students -- as many as one third of those who in the latter part of their second year of college rejected MSE careers -- later returned to the MSE pipeline or, as we prefer, an MSE pathway.

Table 8

First Follow-Up Status Versus Second Follow-Up Status

	Second Follow-Up						
First Follow-Up	No Evidence of Persistence	Left, Some Interest	Left, Definite Interest	Majoring in MSE	BS Degree	Full Persistence	TOTAL
Rejectors	142	15	5	56	10	24	252
Dropouts	2	1	2	2	0	0	7
MSE stopouts	13	8	3	9	1	0	34
Transfers	553	5	6	22	4	8	598
Persisters	181	52	24	644	133	505	1539
Others	36	11	1	10	0	0	58
TOTAL	927	92	41	743	148	537	2488

Somewhat different results can be reported for MSE stopouts. Of the 34 sample members who had left MSE study but said they intended to return to it at some later time, only 10 were found to be majoring in MSE fields at the time of the second follow-up. In addition, only a small fraction of the students who transferred out of MSE study returned to MSE majors (34 out of almost 600 transfers).

At the other end of the spectrum are the students who were categorized as persisters as of the first follow-up. Of the 1539 students persisting as of the first follow-up only 12 percent showed no evidence of persisting as of the second follow-up and one third of them displayed full persistence; thus, students' intentions early in college appear to be excellent predictors of later status provided the intentions are positive with respect to a career. But, if they are negative,

that is, the students have rejected a particular career, we cannot be as certain that they will not later change their attitude towards that career.

Characteristics of Follow-Up Groups

In general, the unique characteristics of the second follow-up groups were the same as the characteristics of the first follow-up groups, although with the longer-term criteria there were more differences among the groups. Table 9 summarizes the differences among the groups in the responses to the Student Descriptive Questionnaire which the students completed when they made application to take the SAT as high-school seniors. For example, 59 percent of the persisters reported that they were in the top tenth of their high school class, whereas 49 percent of the transfers (students who transferred to non-MSE majors) gave the same report, and likewise, 48 percent of the balance of the sample. Summarizing this table, we can say that the persisters: had higher math and science grades and higher class standing, took more years of math and physical science, were more likely to have taken college math and physics in high school, had higher educational aspirations, were more likely to have a mother with a graduate degree, and were less likely to have participated in journalism, debating, or drama than the transfers or the other students.

Table 9

Percentage of Each Outcome Category Having Certain Characteristics (Items 5 to 63, SDQ)

	Item Number	Persisters	Transfers	Others	p[1]
	Minimum N	1330	381	762	
5	In top tenth of high school class	59	49	48	.000
7	More than four years of high school math	33	30	25	.002
10	Three years or more of physical science	56	46	45	.000
13	"A" grade in high school mathematics	64	52	49	.000
15	"A" grade in biological science	65	54	55	.000
16	"A" grade in physical science	62	49	46	.000
18B	College math taken in high school	61	53	49	.000

Table 9 (continued)

		Persisters	Transfers	Others	p[1]
18E	College physics taken in high school	32	27	22	.000
19	Worked less than six hours/week in high school	63	59	55	.000
22	Participated in high school clubs and organizations	92	88	91	.020
23	Five or more honors received in high school	30	29	24	.046
24	Aspire to MA, MS, PhD, or MD	78	69	73	.001
27	Plan to apply for financial aid	93	93	90	.042
39	Father with graduate degree	27	22	24	.047
40	Mother with graduate degree	19	13	13	.001
45A	Participated in athletics	71	64	70	.033
45C	Participated in journalism, debating, or drama	29	35	32	.035
63	Expects career other than MSE	40	39	52	.000

[1]Significance level of chi-square

High School Experiences

As shown in Table 10, enrollment in honors courses in mathematics and science, and enrollment in advanced placement courses in mathematics and science, was an influential experience for a higher proportion of the persisters than for the transfers and others. Also, participation in a college-based minority MSE recruitment/enrichment program as well as industry-sponsored MSE programs were uniquely influential for the persisters although relatively few of the persisters participated in such programs (9 percent). Surprisingly, participation in a number of other programs was not uniquely influential for the persisters. These include career days; museum/university/research center based MSE projects; science fairs; science and math clubs; and enrollment in special math/science or college prep magnet schools. Why these programs in special schools were not uniquely influential for the persisters is not clear. This result clearly requires further investigation.

College Experiences

Table 11a shows the percentage of each outcome category participating in certain college programs and having certain experiences. Not surprisingly the persisters reported that they

found their courses in math, sciences, or engineering to be of intrinsic interest. Perhaps of more interest is the report that a much higher percentage of the persisters (92 percent) than the transfers (77 percent) or the others (60 percent) experienced MSE instructors with knowledge, ability, and teaching skill. How these items were correlated with persistence will be described shortly.

Table 10

Percentage of Each Outcome Category Reporting Certain High-School Enrichment or Recruiting Programs were of Medium or Great Influence (Item 1, PES)

		Persisters	Transfers	Others	p[1]
	Minimum N	1254	369	712	
a.	Honors courses in mathematics	58	46	48	.000
b.	Honors courses in science	54	44	42	.000
c.	Advanced Placement, Mathematics	41	38	31	.000
d.	Advanced Placement, Sciences	34	33	27	.000
e.	Special math/science or college-prep magnet school	16	14	12	.328
f.	Career fairs or math/science career service days	23	23	19	.003
g.	Museum/university/research center based MSE project (please describe)	10	13	9	.232
h.	Science Fair/independent research project (please describe)	12	13	7	.000
i.	Minority professional recruitment program: e.g., Society of Black/Hispanic engineers (please specify)	13	10	10	.052
j.	College based minority MSE recruitment/enrichment program (please specify)	18	12	12	.001
k.	Female MSE recruitment/enrichment program (please specify)	2	1	1	.026
l.	Science, math clubs	21	24	15	.000
m.	Industry sponsored MSE programs	9	5	6	.003
n.	Other (please describe)	24	21	17	.238

[1]Significance of chi-square based on cross-tabulation of the three outcome categories vs. five response categories ("Not available" to "Available, great influence").

Table 11a

Percentage of Each Outcome Category Participating in Certain College Programs and Having Certain Experiences (Items 10 & 19, PES)

		Persisters	Transfers	Others	p
	Minimum N	1463	397	784	
a.	A bridge, or transitional, MSE program between high school and college	18	13	9	.000
b.	College science/math courses that strengthened my basic skills	82	74	66	.000
c.	Tutoring in math/science	36	33	27	.000
d.	Course in communications skills for science and technology	23	19	14	.000
e.	Course for study skills or problem solving	34	32	26	.008
f.	Access to and use of computers	78	71	67	.000
g.	Intrinsic interest of my courses in math, sciences, or engineering	95	81	59	.000
h.	Advice and support from advanced students from my ethnic group	68	57	40	.000
i.	Knowledge, ability, and teaching skills of my MSE instructors	92	77	60	.000
j.	Hands-on experience in laboratories	85	76	62	.000
k.	Teamwork with my classmates	88	78	68	.000
l.	Minority and/or female role models and advisors	59	52	39	.000
m.	My intellectual growth in college	96	92	83	.000
n.	Adequate financial aid	67	65	53	.000
o.	MSE related work opportunities	61	42	25	.000
p.	Professional career/academic counselling	59	48	45	.000
q.	Dedicated minority relations staff	42	35	27	.000
r.	My enjoyment of my chosen major field	96	82	62	.000
s.	Found an MSE field to which I can make a commitment	89	69	33	.000

Intended major. Table 11b indicates that those who intended to attend college and to major in MSE fields were most likely to persist if they planned to major in engineering (61.6 percent). Physical science was second with 57.5 persisting. With the exception of agriculture majors with only 8 cases, those least likely to persist were those who intended to major in mathematics (40.7 percent).

Table 11b

Percentage Persisting in Second Follow-Up by First Choice of Intended College Major (SDQ61)

	N	Persisters	Transfers	Others
Biological Science	193	45.1	13.5	41.9
Computer Science	385	49.1	17.1	33.8
Engineering	1185	61.6	13.2	25.2
Mathematics	113	40.7	19.5	39.8
Physical Science	134	57.5	14.2	28.4
Medical Professions	581	48.9	17.7	33.4
Agriculture	8	25.0		75.0
Architecture	84	51.2	21.4	27.4
TOTAL	2683	1458	410	815

P of Chi-Square = .000

Table 12 shows the percentage of each outcome category who reported they were very satisfied with certain aspects of their education. In general, the persisters reported more satisfaction with their intellectual growth and the intellectual life of the school they attended. A much higher percentage of the persisters (50 percent) reported they were very satisfied with their MSE course offerings. Only 33 percent of the transfers and 28 percent of the others reported such satisfaction.

Persons Influencing Career Plans

As shown in Table 13, the most influential person as far as career plans were concerned were the subjects themselves, as observed in the case studies. Ninety six percent of the persisters reported they motivated their own interest in MSE, as opposed to 92 percent of the transfers and 86 percent of the others. It is of interest, however, that next in line were science\mathematics teachers (71 percent) who were cited more often than parents (65 percent), and they were followed by friends (47 percent) and classmates (45 percent). One third of the persisters marked high school counselors. There was no significant difference between

persisters and non-persisters in the percentage who perceived guidance counselors as an important influence.

Table 12

Percentage of Each Outcome Category Very Satisfied with Certain Aspects of Their Education (Item 12, Postsecondary Experience Survey (PES)

		Persisters	Transfers	Others	p
	Minimum N	1438	392	784	
a.	Ability, knowledge, and personal qualities of most instructors	36	36	36	.342
b.	The social life on campus	30	29	33	.472
c.	Development of my work skills	23	19	20	.101
d.	My intellectual growth	41	38	37	.001
e.	Counseling or job placement	16	12	10	.003
f.	The buildings, library, equipment, etc.	39	40	43	.090
g.	Cultural activities, music, art, drama, etc.	25	27	31	.218
h.	The intellectual life of the school	30	32	34	.040
i.	Course curriculum	34	32	32	.031
j.	The quality of instruction	31	29	33	.513
k.	Sports and recreation facilities	38	38	41	.413
l.	The financial cost of attending	23	23	22	.293
m.	The prestige of the school	51	42	47	.007
n.	MSE course offerings	50	33	28	.000
o.	The racial/ethnic/gender climate	23	19	20	.241

Demographic Variables

Gender. As shown in Table 14, the total analysis sample is two-thirds male and one-third female which tells us only that twice as many men as women met the requirements for inclusion in the sample. In other words, twice as many men had SAT math scores of 550 or more and indicated in filling out the Student Descriptive Questionnaire that they intended to enroll in college and major in one of the MSE fields. This distribution is not surprising considering the widely discussed fact that males taking the SAT have somewhat higher SAT math scores than women and also display more interest in MSE fields.

Table 13

Percentage of Each Outcome Category Reporting Certain People were of Medium or High Influence in Their MSE Plans (Item 2, PES)

		Persisters	Transfers	Others	p
	Minimum N	1413	404	780	
a.	Mother/stepmother/female guardian	65	59	57	.000
b.	Father/stepfather/male guardian	65	59	57	.000
c.	Sister and/or brother	30	29	26	.441
d.	Other family member(s)	26	24	23	.008
e.	Family friends or personal friends	47	48	46	.270
f.	Science/mathematics teacher(s)	71	68	62	.001
g.	Teacher(s) in other subject(s)	38	40	38	.120
h.	High school counsellor	33	30	33	.974
i.	High school coach	10	8	9	.944
j.	Principal/administrator(s)	11	12	9	.572
k.	Extracurricular math/science project staff	18	18	16	.306
l.	Mentor for an independent math/science project	12	11	10	.634
m.	Math/science classmates	45	44	38	.001
n.	Other high school friends	33	36	32	.377
o.	I motivated my own interests in MSE	96	92	86	.000
p.	College or university recruiters	26	22	20	.040
q.	Minority scientists, engineers, M.D.	25	21	18	.000
r.	Women scientists, engineers, M.D.	16	12	13	.106
s.	Men scientists, engineers, M.D.	26	22	17	.000
t.	Business/industry representatives	12	11	14	.154
u.	Church or community advisor(s)	8	8	6	.069
v.	Scientists/engineers/physicians at summer or part-time jobs	22	16	15	.002
w.	Supervisor(s) at jobs	12	12	13	.872
x.	Scientists in news, media	26	24	18	.000

As shown in Table 14, a disproportionately large number of high-ability women failed to follow-up on the interests they showed as high school seniors. However, once the women did enroll in math, science or engineering a larger proportion of them than men completed the bachelor degree requirements and a slightly larger proportion were full persisters. Of the women who did enroll in math, science and engineering (51 percent), well over half had either received bachelor degrees or were in the full persistence category after five years, while less than half of the men were. Forty-five percent of the enrolled women were full persisters while only 39 percent of the enrolled men were. Thus, the evidence suggests that once high-ability women decide to undertake MSE careers a higher proportion complete their plans quickly. The moral would seem to be that efforts to increase the production of female MSE degree recipients should concentrate on encouraging women to pursue MSE careers. Of course, we cannot be sure that a higher proportion of women would persist if there were higher proportions in the MSE pipeline, but in the absence of additional evidence this seems like a reasonable working hypothesis.

Table 14

Percentage in Each Persistence Category by Gender

		0	1	2	3	4	5
	N	No Evidence of Interest	Some Interest	Left, Definite Interest	Majoring in MSE	B.S. Degree	Full Persistence
Male	2493	30.7	10.2	5.0	28.0	5.1	21.0
Female	1249	39.6	5.2	4.4	20.7	7.0	23.0

Ethnicity. Table 15 shows the pattern of persistence for each of the six ethnic groups in the study. If we define persistence as Category 3 (majoring in MSE field), Category 4 (B.S. recipient in MSE field) and Category 5 (full persistence), then 53 percent of the total sample persisted. The lowest rate was for American Indians (46 percent) and the highest was for Asian Americans (64 percent). Black students and Puerto Rican students, at 53 and 54 percent

surpassed White students (52 percent) by a slight amount, and American Indian and Mexican American students fell short (46 and 50 percent). By the chi-square test, the overall differences among the ethnic groups in persistence are not significant (p. 10). Other research has shown that Black students typically take longer to complete their requirements for a bachelor's degree, presumably because of their need to interrupt their undergraduate schooling more often than White students in order to replenish their finances. For whatever reason, the longer period of undergraduate study would seem to be true of high ability Black students and also of other minority students, except for Asian-Americans.

Table 15

Percentage in Each Second Follow-Up Category by Ethnicity

	N	No Evidence of Interest	Some Interest	Left, Definite Interest	Majoring in MSE	B.S. Degree	Full Persistence
American Indian	214	35.5	12.1	6.1	25.2	2.8	18.2
Black	1505	32.6	9.0	5.2	26.0	6.9	20.3
Mexican American	910	36.3	9.1	4.7	28.7	4.3	16.9
Asian American	359	29.5	4.2	2.2	22.6	6.4	35.1
Puerto Rican	443	33.0	8.4	5.0	25.1	5.6	23.0
White	311	35.7	7.4	5.1	18.6	5.5	27.7

Influence of Secondary School

Whether the nature and quality of the high school attended had an influence on persistence is the focus of this section. Fully addressing the question is a complex task for we need sensitive measures of a broad range of variables including quality of the teaching and guidance staff, adequacy of laboratory and other educational facilities, the range of courses offered in mathematics and science, the mean ability of students in the school and, perhaps most important, measures of how conducive the climate of the high school is to educational

excellence, particularly in the sciences. Is the high school one with a tradition of excellence in science, with teachers who expect students to perform with distinction? Do the teachers set high standards for themselves and for students, and are the teachers willing to spend extra time with students having difficulty, and have they the time to do this? Does the administration of the school strongly support the teachers efforts to achieve high levels of performance in mathematics and science and other basic subjects? Unfortunately, in the present study we do not have direct measures of most of these variables and instead have had to rely on indirect indicators such as whether the school offers honors courses in mathematics.

A second problem in analyzing school effects is that of isolating the unique effect of school variables when it is known that these are related in complex ways to parental and community variables. It is well-known that parental education and school quality measures are highly related for a number of reasons. More educated parents tend to migrate to communities with high quality schools or at least schools that are reputed to be of high quality. Furthermore, they participate more on school boards and press for teaching advanced courses. We will attempt to ascertain the unique effect of the school through multiple regression but first we will describe the zero order relationship of a broad range of variables to persistence. Then we will estimate the unique contribution to the prediction of persistence by a selection of the variables and by certain scales constructed from the variables.

Numerous other measures that discriminated between the outcome categories are described in the Interim Report. They are not described here since their relationship to the outcome categories did not change from the first follow-up to the second. Copies of the Interim Report are available from ETS as Research Report No. RR-89-28.

Results, Predictive

Multiple Regression

In order to investigate what level of prediction could be obtained from an optimal weighing of available predictors and, also, to estimate what contribution each variable made to the prediction, a conventional step-wise multiple regression was computed. The regression was computed in blocks beginning with three background variables as shown in Table 16.

The "parents living" measure was derived from the Postsecondary Experience Survey (PES) which asked about the extent to which the student's career plans may have been influenced by, first, the student's father and, second, the student's mother. If the questionnaire respondent checked the option "not applicable," we assumed that the father or mother was not present in the home. Obviously, this measure is fallible, but there was no alternative. In fact, many of the measures are not precisely relevant, having been contrived from questionnaire and interview items designed for other purposes.

Block 5 (Early college commitment) was deliberately placed next to last in order to see what level of prediction could be obtained from objective self-report items as compared to the attitude items in Block 5, which in effect asked the respondents to report how committed they were to an MSE career. It would have been surprising, indeed, if the Block 5 measures were not highly related to persistence as measured in the Second Follow-Up three years later, and, in fact, they were moderately correlated with persistence, the product moment correlation of Enjoyment, Interest, and Commitment being .39, .38, and .50 respectively. Thus, measures obtained from the PES which the subjects completed two years after high school graduation were moderately good predictors of persistence three years later.

The mean, standard deviation, correlation, and Beta coefficient of each of the predictors are shown in Table 17. Some comments on the predictors and their relationship to persistence follow.

Table 16

Measures in Multiple Regression

Block 1: Background		
1	PARNLIV	No. of parents presumed present in home. Both parents "Not Applicable" = 0. "Applicable" = 1 or 2. (PES 2a + b)
2	PARED	Parents' education. Sum of father's and mother's education (SDQ 39 and 40)
3	QA3	Parental income. (SDQ 43; midpoints used)
Block 2: Individual		
5	MHIGRADE	Math-science grades equal to or higher than other grades (PES 13 & 14)
7	FIELD 2	Second choice of major MSE = 1, not = 0 (SDQ 62)
6	Q44C	Needs help with math. Yes = 1, no = 0
9	Q18B	Took advanced math in high school. Yes = 1, no = 0 (SDQ 44C)
16	OWN	Provide own interest in high school. Yes = 1, other = 0 (PSE 20)
10	SEX	Female = 2, male = 1 (SAT files)
4	Q16	Physical science grade. Excellent = 4, failing = 0 (SDQ 16)
11	IV24	Acceptable educational attainment. PhD, MD = 8 to high school dip. = 1 (PES 24)
12	SATV2	SAT-verbal (SAT files)
14	Q 23	No. of honors received (SDQ 23)
13	SCIVALUE	Sum of ratings of scientific values (PES 21, m, q, & n)
15	SDQABIL	Mean of self-ratings of mathematical, mechanical & scientific ability (SDQ 53, 54 and 58)

Table 16 (continued)

18	HSEXP	Mean of ratings of high school MSE programs. Not available or no participation = 0 to great influence = 3 (PES 1)
17		SAT-math (SAT files)
19	HSGPA	High school grade point average (SAT files)
8	JOBAGE30	Expects a professional job at age 30 (1) vs. not (0) (PES, 25 B)

Block 3: High School environment

22	HONINF	Influence of honors courses. (PES 1 a + b 0 = neither course influential, 4 = both influential)
20	ADVINF	Advanced Placement influential (PES 1 cd)
21	MSENRICH	No. of high school MSE-related programs (PES 1)

Block 4: College environment & academic success

23	FOURYEAR	Enrolled in four-year college. Yes = 1, no = 0 (PES 3)
24	SATSUM	Sum of MSE-related satisfactions (PES 12, m, n, o)
25	COLAVAIL	Availability of college MSE programs (PES 10 or 19 a, b, c, d, e, f, h, i, j, r, l, n, o, p, q available = 1, not available = 0
26	III13	College GPA (PES 13)
27	COLPART	Participation in college NISE programs See COLAVAIL
28	11114	Math-science GPA

Block 5: Early college commitment

30	Interest	Interest of MSE courses (PES 10 or 19 g.)
29	Enjoyment	Enjoyment of my major (PES 10 or 19 r.)
31	Commitment	Commitment to MSE field (PES 10 or 19 s.)

Table 16 (continued)

Block 6: Ethnicity

32	INDIAN	American Indian (SAT files)
33	PUERTO	Puerto Rican (SAT files)
34	WHITE	White (SAT files)
35	ASIAN	Asian or Pacific Island American (SAT files)
36	CHICANO	Chicano or Mexican American (SAT files)
37	BLACK	Black or African American (SAT files)

Table 17

Mean ($\bar{X}$), Standard Deviation (SD), Product Moment Correlation (r) and Beta Coefficients (ß) with Persistence Scale of Measures in Multiple Regression
Sample: Total (N = 1649 to 3914)

		($\bar{X}$)	SD	r	ß
1	Parents in home	1.9	.4	.05	.00
2	Parents' education	10.0	3.9	.08	.03
3	Parents' income	10.1	4.0	.03	.01
4	Physical science grade	3.4	.7	.18	.00
5	Math grade higher	.7	.4	.22	.08**
6	Math help needed	.1	.3	-.06	-.01
7	2nd choice also MSE	.5	.5	.15	.06*
8	Professional job at age 30	.7	.4	.16	.05*
9	Took advance math	.6	.5	.13	.05*
10	Female (2), male (1)	1.4	.5	-.08	-.06**
11	Educational aspirations	6.3	.9	.19	.04
12	SAT-Verbal	501.8	93.3	.05	-.02
13	Science values	1.7	3.0	.25	.05*
14	Number honors received	2.8	1.3	.10	.00
15	Self-rated ability	3.6	.5	.14	-.03
16	Self motivated	.5	.5	.17	.00
17	SAT-Math	615.0	53.9	.20	.10**

Table 17 (continued)

		$\overline{X}$	SD	r	ß
18	Participation, MSE	2.3	1.8	.16	-.07
19	High school GPA	3.5	.5	.19	.05
20	Number Advanced Placement	1.5	1.5	.16	-.06*
21	Number MSE programs	3.4	3.3	.10	.03
22	Influence, honors	2.0	1.4	.20	.10**
23	Four-year college(1) vs. two-year(0)	.9	.2	.11	.08**
24	MSE satisfactions	11.6	2.2	.18	.03
25	Available college support	13.5	3.1	.22	-.02
26	Early college GPA	4.8	1.2	.25	.16**
27	College participation in MSE activities	7.8	3.3	.31	.07*
28	Math-science GPA	4.8	1.5	.27	-.03
29	Enjoyment, MSE	.8	.4	.39	.08**
30	Interest, MSE	.8	.4	.38	.07**
31	Commitment, MSE	.7	.5	.50	.30**
32	American Indian	.1	.2	-.06	-.03
33	Puerto Rican	.1	.3	.00	-.03
34	White	.1	.3	.02	-.01
35	Asian American	.1	.3	.09	-.01
36	Mexican American	.2	.4	-.04	-.03
37	Black	.4	.5	-.01	N.A.

* Significant at the .05 level
** Significant at the .01 level

Discussion of Predictors

1. Parents in home.

   As noted earlier, this measure was created to reflect how many parents were present in the sample member's home. Evidently, either our theory or method was not valid for the correlation of the item with persistence is negligible. It also is of interest that only a small fraction of the sample members reported that one or both parents were "not applicable."

2. Parents' education.

   This variable is only slightly related to persistence in MSE fields.

3. Parents' income.

   Surprisingly this variable is even less related to persistence than parents' education. A possible interpretation is that although sample members with wealthy parents have the funds to continue their education without interruption they also have the means to transfer to other fields if they find MSE study unsatisfactory and, thus, that parents income, on balance, has no simple linear relationship to persistence.

4. Physical science grade.

   Nearly all members of the sample had the highest physical science grade in high school which may explain why physical science grade has only a small relationship with persistence: there is little range in the measure.

5. Math grade higher.

   We hypothesized that rather than the absolute level of grades in various subject areas it is the relative level of grades that is an important determinant of career choice. The student with B grades in math and science courses and A grades in non-science courses will be less committed to MSE fields than a student with B grades in math and science courses and C grades in non-science fields. The results would seem to support this hypothesis.

6. Math help needed.

   If, in responding to the Student Descriptive Questionnaire (SDQ) as a high school senior, the sample member indicated that he or she may need help in mathematics it would augur ill as far as persistence in MSE fields is concerned.

7. Second choice also MSE.

   The SDQ asked students to indicate both their first and second choice of college major. If the sample members indicated that both choices were in MSE fields, then the probability

of their persisting in the MSE fields apparently is higher than for students who name some non-MSE field as their second choice.

8. MSE job at age 30.

   Sample members indicating they expected to have a professional job at age 30 received a score of 1, while the others (mostly managers, elementary and secondary school teachers, technicians or military service personnel) received a score of 0. College teachers or researchers were included in the professional group.

9. Students who completed advanced high school or college-level work in mathematics during high school had a slightly higher probability of persisting in college.

10. Female vs. male.

    Female sample members were less likely to persist in math, science or engineering. Some reasons for this will be discussed shortly.

11. Educational aspirations.

    Since this item in effect asks the respondents whether they expect to persist in college and/or graduate school it is not surprising that it correlates with persistence in MSE programs.

12. SAT-Verbal.

    This variable was included with the expectation that it would correlate negatively with persistence in MSE majors. This is, in fact, the case when the prediction problem is to predict persistence versus transfer. Apparently students who have high verbal scores have a strong tendency to transfer from MSE fields to non-MSE fields.

13. Science values.

    This measure, obtained when most sample members were sophomores in college, is one of the strongest predictors of persistence three to four years later. This is not surprising;

indeed, it would be surprising if persisters did not regard as important "making practical scientific technological contributions" and "contributing to basic science theory."

14. Number of honors received.

    Since this item concerns academic honors in general and not simply academic honors in math and science subjects, it is not surprising that it is only weakly related to persistence in MSE fields.

15. Self-rated ability.

    The self-ratings of mathematical, mechanical, and scientific ability were expected to have a stronger relationship with persistence. Possibly high school seniors do not have an especially accurate self-perception in these areas or maybe the high school seniors taking the SAT were motivated to present themselves in the best possible light, resulting in the measure not having much spread (SD = .05).

16. Self-motivated.

    Item 3 of the PES asked the respondents to indicate the extent to which a long list of individuals (e.g., mother, father, teachers) influenced their decision to study math, science or engineering. Those who selected "I provided my own motivation" tended to have substantially higher persistence scores than the balance of the sample. We assume the item is a measure of self-directedness.

17. SAT-Math.

    Although all members of the sample were selected to have SAT-math scores of at least 550, there still is enough range in the variable for it to be a good predictor of persistence. This supports our hypothesis that having the requisite abilities increases the probability of success.

18. The PES asked respondents to indicate the extent to which each of a long list of math-science activities and supports were important to them in high school. The smallness of

the correlation suggests that students dedicated to math-science careers did not necessarily participate in a large number of activities related to math and science.

19. High school GPA.

    There was a small correlation between overall high school grades and persistence in MSE, but GPA did not predict as well as some other measures of achievement, such as SAT math score.

20. Number of advanced placement courses.

    There was a small correlation between persistence and number of advanced placement math and science courses, but this variable did not contribute to the prediction when other achievement measures were included in the prediction equation.

21. Number of MSE programs.

    This measure was created to reflect the MSE support provided by the high school attended by the respondent. Respondents indicated which of a long list of MSE activities and support were available to them. There was a very small correlation between the number of available programs and MSE persistence.

22. Influence of honors courses.

    Students who reported that they were enrolled in honors courses in math and science were more likely to persist than those not checking this item. We interpret this result to mean that students taking honors courses were better prepared for MSE study in college.

23. Four-year college.

    Most sample members were enrolled in four-year colleges when they completed the PES as sophomores. The few (ten percent) who were enrolled in two-year colleges were substantially less likely to be persisters three years later during the second follow-up. We assume this item reflects the well-known slippage in the transfer from two-year to four-year colleges.

24. MSE satisfactions.

    We asked the respondents to indicate how satisfying they found a number of activities related to MSE study. The sum of these satisfactions has a small correlation with persistence.

25. College supports.

    This item concerning the availability of college support systems parallels the similar item for high school support systems. The number of such systems available to the student is correlated with persistence but has a negative beta weight, presumably because it acts as a suppressor variable.

26. Early college GPA.

    The sample member's grade point average after 1 1/2 semesters of college is one of the best predictors of persistence. This is not at all surprising since GPA is in reality an intermediate index of persistence and also in view of the fact that academic failure or mediocre grades is a major reason for a student to either withdraw from school or seek another major.

27. College participation.

    Participation in a broad range of MSE-related programs is a moderately good predictor of persistence.

28. Math-science GPA.

    Math-science GPA after 1 1/2 semesters (that is, in the spring of the sophomore year) is a slightly better predictor of persistence then GPA in general.

29. Enjoyment of MSE.

    Not surprisingly, students who report that they particularly enjoy their study of math, science or engineering have a higher probability of persisting three years later than students who did not report so.

30. Interest in MSE.

Similarly students who in their sophomore year say they are interested in math, science and engineering have a higher probability of persisting three years later than those who say they are less interested.

31. Commitment to MSE fields.

Likewise students who report they are committed to an MSE major are likely to persist three years later. It would be very surprising if the results were otherwise.

32-37. Ethnic identification.

When scored as dummy variables and entered into the regression as one block, none of the individual ethnic variables is significantly related to persistence and, as a block, they do not contribute significantly to the multiple regression. In other words, when a large number of other variables are taken into consideration, knowledge of a student's ethnicity contributes nothing to the prediction of persistence. This is not to say that ethnic identification is not an important variable in persistence or student development in general. Innumerable studies have demonstrated that this is not the case. What an Hispanic student experiences in an undergraduate school is clearly different from Black student experiences which in turn is clearly different from what a White experiences. What these results do indicate is that in predicting persistence from the measures available in this study, ethnic variables explain a negligible about of additional variances when all of the available measures are in effect held constant.

It is of interest to ask in what ways the ethnic groups differ as far as the variables in this study are concerned. Table 18 presents an inventory of these differences. These means suggest the following generalizations as far as our particular sample is concerned.

1. The parents of the Mexican American sample numbers are less well educated and less affluent than the other parents.
2. A higher proportion of the black students expected to need help in mathematics.

3. Fewer of the American Indian students expected to have a professional job at age thirty.

4. A higher proportion of the Black and Asian American sample members were female.

5. The Asian American sample had the highest educational aspirations, and the American Indian sample had the lowest.

6. The Black and Puerto Rican students had the lowest SAT-verbal scores. (A substantial number of the Puerto Rican students lived and attended school in Puerto Rico).

7. Black students had the lowest SAT-math scores and the Asian American students the highest.

8. Black students reported they participated the most in MSE-related activities in high school.

9. Black and American Indian students had the lowest GPAs in high school.

10. Black students derived the least satisfaction from MSE activities but reported the most college support systems. They also reported the highest math-science GPAs.

Gender differences. It is also of interest to examine the mean differences between males and females on the predictors to see some reasons why females were less likely to persist in MSE fields. From Table 19 we see the following:

1. The men were more likely than the women to have higher math grades than non-math grades.

2. Somewhat fewer of the men expected to have a professional job at age 30.

3. The men had slightly lower educational aspirations than the women.

4. The men had significantly lower SAT-verbal scores.

5. The men had higher science values but received fewer honors than the women.

6. The men rated themselves slightly lower than the women in science and engineering ability.

7. The men had higher math grades but participated less in MSE activities in high school and had slightly lower high school GPAs.

8. Few men reported they were influenced in their MSE careers by high school honors courses.
9. The men reported slightly higher GPAs early in college.
10. Early in college the men reported more interest and commitment to MSE careers.

The last item is probably the most significant. Even though the women had higher scores than the men on many of the predictors -- with the notable exception of SAT math scores -- the women early in college (at the time of the first follow-up) reported less interest and commitment to MSE careers than the men. The full explanation of this phenomenon deserves further research. For example, did the women find the college environment less encouraging and supportive than the men did?

Table 20 shows the product moment and multiple correlation of blocks of variables with persistence. This table suggests the following conclusions:

1. Background variables provided a trivial amount of explanation of persistence.
2. Individual variables added considerably to prediction but still only accounted for roughly one fifth of the variance.
3. The predictive individual variables were partly motivational (aspirations and values) and partly ability, especially quantitative ability.
4. High school variables added slightly to the prediction.
5. The nature of the early college environment and the student's involvement in MSE activities in that environment added moderately to the prediction.
6. The student's self-reported commitment to an MSE career early in college added somewhat more to the prediction.
7. Ethnicity added a zero amount to the prediction when added last to the multiple regression.
8. The final equation explained only about one third of the variance, leaving two thirds of the variance in persistence unexplained.

Table 18

Mean Scores on Predictors by Ethnicity

		American Indian	Black	Mexican American	Asian American	Puerto Rican	White
1	Parents in home**	1.9	1.8	1.9	1.9	1.9	2.0
2	Parents' education**	10.2	10.3	8.3	11.5	10.3	10.8
3	Parents' income**	10.4	9.7	9.3	11.7	10.1	11.7
4	Physical science grade	3.4	3.3	3.5	3.6	3.5	3.6
5	Math grade higher	.8	.7	.7	.8	.7	.7
6	Math help needed**	.12	.16	.14	.13	.09	.07
7	2nd choice also MSE	.7	.7	.7	.8	.7	.7
8	Professional job at age 30**	.6	.7	.7	.8	.8	.7
9	Took advanced math	.6	.5	.5	.7	.6	.5
10	Female-2, Male-1**	1.27	1.44	1.28	1.38	1.29	1.30
11	Educational aspirations**	6.9	7.1	7.0	7.2	7.0	7.0
12	SAT-Verbal**	514	496	505	537	497	538
13	Science values	2.1	2.2	2.3	2.2	2.6	1.9
14	Number of honors received*	2.5	2.8	2.8	2.9	2.8	2.6
15	Self-rated ability*	3.6	3.5	3.6	3.6	3.6	3.6
16	Self-motivated*	.68	.71	.74	.69	.75	.64
17	SAT-Math**	618	602	615	650	614	643
18	Participation, MSE**	2.0	2.7	2.1	2.1	2.1	1.7
19	High School GPA	3.4	3.4	3.5	3.6	3.6	3.6
20	Number Advanced Placement*	1.7	1.5	1.4	1.7	1.5	1.5
21	Number MSE programs	4.6	5.6	4.8	4.8	4.6	3.9
22	Influence, Honors	2.0	2.0	1.9	2.1	2.0	1.9
23	Four-year college	.88	.96	.93	.97	.96	.93
24	MSE satisfactions**	11.8	11.3	11.7	11.8	12.1	11.7
25	Available college support**	13.0	13.9	13.5	13.5	13.1	13.0
26	Early college GPA	3.1	3.4	3.2	2.7	3.0	2.9
27	College participation	7.2	8.6	7.3	7.4	7.4	6.9
28	Math-Science GPA**	3.2	3.6	3.4	2.9	3.2	3.1
29	Enjoyment, MSE	.8	.8	.8	.9	.9	.9
30	Interest, MSE	.8	.8	.8	.8	.8	.9
31	Commitment, MSE	.7	.7	.7	.7	.7	.7

*One-way F Test is significantly different at the .05 level.
**Significant at .01 level.

Table 19

Mean and Standard Deviation of Predictors of Persistence by Gender

		Male		Female	
		$\bar{X}$	SD	$\bar{X}$	SD
1	Parents in home	1.9	.4	1.9	.4
2	Parents' education**	9.7	3.9	10.4	3.8
3	Parents' income	10.0	3.9	10.2	4.0
4	Physical science grade*	3.4	.7	3.5	.7
5	Math grade higher**	.75	.43	.66	.48
6	Math help needed*	.13	.3	.16	.4
7	2nd choice also MSE*	.73	.4	.62	.5
8	Professional job at age 30**	.69	.46	.77	.42
9	Took advanced math	.57	.5	.55	.5
10	Female-2, Male-1**				
11	Educational aspirations**	6.2	.9	6.4	.9
12	SAT-Verbal**	501.7	92.2	517.0	90.8
13	Science values**	2.4	3.4	1.9	3.0
14	Number of honors received**	2.6	1.3	3.0	1.3
15	Self-rated ability*	3.5	.48	3.7	.49
16	Self-motivated*	.71	.5	.73	.4
17	SAT-Math**	622.0	56.8	605.9	49.0
18	Participation, MSE**	2.2	1.7	2.4	1.8
19	High School GPA	3.4	.5	3.6	.3
20	Number Advanced Placement*	1.5	1.5	1.6	1.5
21	Number MSE programs	5.0	2.8	5.0	2.8
22	Influence, Honors	1.9	1.5	2.1	1.4
23	Four-year college	.94	.24	.96	.21
24	MSE satisfactions	11.7	2.2	11.5	2.2
25	Available college support	13.6	3.1	13.4	3.0
26	Early college GPA**	3.3	1.2	3.0	1.2
27	College participation	7.7	3.3	7.9	3.2
28	Math-science GPA	3.3	1.6	3.3	1.6
29	Enjoyment, MSE	.83	.37	.83	.38
30	Interest, MSE**	.84	.37	.79	.41
31	Commitment, MSE**	.71	.45	.65	.48

*One-way F Test is significantly different at the .05 level.
**Significant at .01 level.

Table 20

Product Moment and Multiple Correlations of Blocks of Variables with Persistence
Sample: Total, with social science as non-MSE and premedical and predental students excluded
N = 3914 (Minimum pairwise N = 1649)

	Background		Individual		High School		Early College		Commitment		Ethnicity	
Cum. R:	.09		.43		.44		.52		.61		.61	
Sig. Change	.01		.00		.00		.00		.00		.52	
		r		r		r		r		r		r
	No. of parents	.05	H.S. GPA	.19					Interest	.38	American Indian	-.04
	Parents' ed	.08	Self-motivated	.17	Honors courses	.20	Supports available	.22	Enjoyment	.39	Puerto Rican	.00
	Family income	.03	Educational aspirations	.19	Advanced placement	.16	Four-year college	.11	Commitment	.51	Asian American	.09
			Math grades higher	.22	Science enrichment	.10	Early GPA	.25			Mexican-American	-.04
			SAT-Math	.20			Satisfying school	.18			White	.02
			Took adv. math	.13			Math-science GPA	.27			Black	-.01
			Science values	.25			College participation	.31				
			H.S. experience	.16								
			SAT-Verbal	.05								
			Professional	.16								
			Gender (F)	-.08								
			Honors	.10								
			Science grade	.18								
			MSE abilities	.19								
			Need math	-.06								
			Self rating	.14								
			2nd major	.15								

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Discussion of Multiple Regression

Why the multiple regression accounts for only 36 percent of the variance is an important question to which there are several answers. First, it is highly likely that important variables were not adequately measured. We suspect that chief among these are better measures of the environmental press of both the high school and the college environment. How conducive was the environment of each high school and each college to rewarding accomplishment in studying math, science, and engineering? Did the sample members find the study of MSE subjects exciting and highly satisfying or was the study boring, tiresome, and tension provoking? Also, in the case of women and minorities in particular, was the sample member discouraged by faculty members and counselors from advanced study?

Another category of variables concern the way in which the sample member perceived the economic environment. Was the sample member led to believe there would be a strong demand for members of a particular specialty, computer science, for example? Or did the subject perceive a lack of job opportunities in a particular field, architecture, for example?

An effort was made to measure all of the preceding variables, but we suspect the measures were not of sufficient validity.

A second reason for limited explanatory value of the regression concerns attenuation for which there was no correction. It is likely that if there had been a correction for attenuation the proportion of variance explained would have been considerably larger. What is urgently needed is a reanalysis of the data by means of structural equations. This is, in fact, being done in a new phase of this line of research under the leadership of Jerilee Grandy at ETS.

The third cause of the limited value of the multiple regression concerns the inherent unpredictableness in the process of persistence. To some unknown extent an individual's persistence in any endeavor is unpredictable due to relatively unpredictable chance events in the environment, for example, death of a relative, closing of a school, a military draft, or a personal

illness. These are events over which the individual has little control and which cannot be included in a predictive equation no matter how clever the researcher is.

The conclusions from the first phase of this line of research, as summarized in the Interim Report, remain unchanged. None of the results of the Second Follow-Up alter these conclusions. Briefly summarized they were as follows:

1. Compared to other student populations, the high-ability minority students in this study persisted in MSE fields to an unusually high degree.
2. In investigating the causes of attrition of MSE majors, sharp distinctions must be made among certain categories of students who withdraw, specifically, among transfers and "MSE leavers."
3. Leaving the MSE field is not necessarily an undesirable educational outcome.
4. The characteristics and experiences of persisters differ markedly from those of transfers, which, in turn, differ markedly from those of MSE leavers.
5. In general, what distinguished the persisters most from the balance of the sample was their finding the study of math, science, or engineering at the college level enjoyable and interesting, and their personal commitment to MSE as a career.
6. Persisters were more likely to have participated in advanced high school math and science courses and related extracurricular activities.
7. Persisters generate their own interest in science and minority persisters are influenced by minority scientists and engineers.
8. Early college level variables are the most important predictors of persistence.
9. Among high-ability minority students, ethnicity per se contributes little to the prediction of MSE persistence when other individual characteristics and environmental variables are taken into consideration.

10. The major reasons cited for not attending any college or attending college and withdrawing were financial.

11. At each educational transition point, there is substantial flow into as well as out of the MSE pipeline.

Additional Conclusions

We would now like to offer some additional conclusions, based largely on the results of the second follow-up of the sample, but also on further consideration of the results of the First Follow-Up.

12. The high persistence of our sample's high-ability minority students that was observed in the first two years of college continued through the last two years of college. Numerous studies of High School and Beyond data indicate that this is not true of students in the general population, particularly minority students, suggesting that the continuation of high persistence through the last two years of undergraduate school is a phenomenon unique to high-ability students.

13. Persisting in science is the outcome of the highly complex process in which many variables interact; if we find any correlation between two variables it is only because on the average the two variables tend to be related in the same way. This is probably why the zero-order correlations among various variables tend to be low. Under some circumstances or for some subgroups two variables may have a positive correlation, while under other circumstances, the same two variables may even have a negative correlation, the net effect being low or zero correlations among variables when the data from large heterogeneous samples are pooled.

14. There is a large element of chance in the career development of any individual. Two individuals with highly similar personal characteristics will develop at different rates

along different pathways depending on purely chance events or the fortunate or unfortunate timing of environment events. This is why multiple correlations are low even though we may have a good criterion and reliable predictors.

15. Examining the predictors by blocks, family background has only a trivial relationship with persistence. Possibly this relationship would have been stronger had we had a more heterogeneous sample.
16. Individual variables are somewhat more related to persistence and probably would have been even more related if we had a probability sample of the general student population.
17. Characteristics of the high school attended by sample members did not contribute substantially to prediction of persistence. To some extent this was attributable to covariation between individual characteristics and high school characteristics. Good students tend to attend the better high schools and to perform better at these high schools.
18. The students' academic experience and, to a lesser extent, social experiences during the first two years of undergraduate school are the most important determinants of persistence.
19. The decision to persist on the part of an individual is not irrevocable and not necessarily long lasting. Circumstances change and individual beliefs and attitudes change. This is why it is important for colleges and universities to provide for mobility from one curriculum to another. Faculty, administrators, and counselors should recognize that a student's career goals are not immutable and should provide for their change. This is probably the most important conclusion from this study.

Caveats. In addition to the caveats pointed out in the report on the first follow-up (Hilton et al., 1989) -- mainly concerning possible nonresponse bias and problems of causal

inference -- other items have come to our attention. Clifford Adelman (personal communication to María Pennock-Román) has convincingly demonstrated that estimates of graduate school attendance "taken only seven years after high school graduation substantially underestimate graduate school attendance," and in general that transcript data are far superior to survey data as far as school enrollment estimates are concerned. This is a serious problem and we would caution the reader not to rely too much on attainment rates obtained from short-term longitudinal data as those reported here, particularly when comparing the attainment of various ethnic groups. Some groups simply may take longer to achieve certain levels of attainment.

Also we remind the reader that the data were pooled across a large number of diverse colleges and universities, thus obscuring important differences in interactions and outcomes. Future research in this area should be mindful of this.

References[4]

Astin, A. W. (1982). Minorities in American higher education: Recent trends, current prospects and recommendations. San Francisco: Jossey-Bass.

Guba, E. G. (1978). Toward a methodology of naturalistic inquiry in educational evaluation (Monograph Series No. 8). Los Angeles: Center for the Study of Evaluation, University of California.

Hilton, T. L. (1962). Career decision-making. Journal of Counseling Psychology, 9, 291-298. Also in B. Hopson & Hayes (Eds.), 1968, The theory and practice of vocational guidance. New York: Pergamon Press.

Hilton, T. L. (1982). Persistence in higher education: An empirical study (College Board Report No. 82-5, ETS RR No. 82-44). New York: The College Board.

Hilton, T. L., & Schrader, W. B. (1987). Pathways to graduate school: An empirical study based on national longitudinal data (Final Report, GRE No. 82-21R), Princeton, NJ: Educational Testing Service.

Murray, H. A. (1938). Explorations in personality. New York: Oxford University Press.

National Center for Education Statistics. (1989). College persistence and degree attainment for 1980 high school graduates: Hazards for transfers, stopouts, and part-timers (CS 89-302). Washington, DC: Author.

Office of Educational Research and Improvement. (1987). OERI directory of computer tapes. Washington, DC: Author.

Olivas, M. A. (1986). Latino college students. New York: Teachers College Press.

Patton, M. Q. (1980). Qualitative evaluation methods. Newbury Park, CA: Sage.

Simon, H. A. (1955). A behavioral model of rational choice. Quarterly Journal of Economics, 49, 99-118.

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[4]Additional references are listed in the final report of Phase I, which is attached.

Solorzano, D. G. (1988). Persistence in math, science and engineering of a national sample of minority students. In T. L. Hilton (Ed.), Persistence in science of high-ability minority students (pp. 57-68). Princeton, NJ: Educational Testing Service.

Stake, R. E. (1981). Case study methodology: An epistemological advocacy. In W. W. Welsh (Ed.), Case study methodology in educational evaluation. Proceedings of the 1981 Minnesota Evaluation Conference. Minnesota Research and Evaluation Center.

Tinto, V. (1987). Leaving college: Rethinking the causes and cares of student attrition. Chicago: The University of Chicago Press.

Appendix A

Second Follow-Up Telephone Tracking Procedure

APPENDIX

Second Follow-Up Telephone Tracking Procedures[1]

Step 1: Contact Procedure. We called the contact person (using the 1987 contact phone number). If we were able to reach the contact, usually a parent or close friend, we asked for both the current phone number and the address of the respondent. If the respondent didn't have a phone number, we would leave our 800 number with the contact and would have the respondent call us back.

Step 2: Student Procedure. If the contact's phone number was no longer valid, we would then try the respondent's phone number (the 1987 phone number we got from ETS). If the respondent's number was also invalid, we would then use the Telephone Directory Assistance Service to find out the phone listings for both the contact person and the respondent. In cases where the contact and the respondent lived in two different cities, we would have to make two directory assistance inquires.

Step 3: School Procedure. If we were unable to reach the contact and/or the respondent, we would call the school which the respondent reported in the 1987 survey. We used Telephone Directory Assistance to obtain the school numbers, and assigned interviewers who were tactful in interacting with school administrative staffs over the phone.

In calling the schools, the interviewers would first ask to speak with the Registrar's/Records Office. If the Registrar's/Records Office did not have any information on the respondent (maybe due to the fact that R have graduated or dropped out, or didn't correctly report his/her school in the 1987 survey), the interviewers would ask to be transferred to the Alumni Office. If the Alumni Office did not have any information on the respondent, the interviewers would try the respondent's major department. In cases which a school cannot give out student information due to

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[1]This section was written by Man Tsun Cheng

"confidentiality" issues, we would ask them whether they would be able to forward any correspondence to the respondent.

Second Follow-Up Letter Tracking Procedures

Besides using telephones to track cases, we also sent out letters in situations where telephone contacts seemed to have failed. To decide which address and to whom we should send letter to (e.g., to respondent directly, to contact and ask for respondent's address, phones, and pass our 800 number along to the respondent, or to school forwarding our letters to the respondent), each case was evaluated based upon his/her tracking records. We sent out letters to those whose address seemed to be still valid and were most likely to relay our messages to the respondent. Among the 826 letters we sent out to track down the 500 at-one-point-not-yet-completed cases, 39 percent were sent to the contact persons, 44 percent to the respondents, and 17 percent to the schools to be forwarded to the respondents. The addresses we sent letters to may or may not be the 1987 addresses we got from ETS, because for some cases we were able to obtain updated addresses during our telephone tracking processes (either from the contact persons, the school administrative staffs, or from the returned mail label.) Each returned letter was examined. In cases where the postal office refused to forward the letter (due to expired forwarding period) and yet printed the updated addresses on the labels, we would re-send the letters with the more recent addresses we got from the returned mail.

Among the 500 cases we sent letters to, 50 percent were sent one letter, 37 percent two letters, 12 percent three letters, and the remaining four letters. The responses to our letters were quite satisfactory. Among these 500 hard-to-track cases, we finally got 44 percent of them to complete our survey.

Second Follow-up Completion Results

Out of the 3224 cases, we were able to track down 92 percent (N = 2952). Among the 2952 cases whom we succeeded in locating, 54 were either in the military forces or out of the country.

However, we did obtain their forwarding addresses. Another three died and one was seriously ill. As for the remaining 2894 cases who were in the country during the survey period, 2883 participated in our survey and only 11 refused to take part.

No upper limit was set on the number of telephone calls we made to track down a case. For each of the 3224 cases, we consistently followed through with tracking procedures, and made as many phone calls as we needed to obtain a completion. For a few cases, the number of calls we made were as many as 40. However, the average number of calls we made in this survey was 5.1, and the average number of contacts (actually talked to someone on the phone) were 4.2. If we divide the 3224 cases into the group of completions and the group of non-completions, the mean numbers of calls and contacts we made to non-completions are actually higher than the numbers we made to completions (7.8 vs. 4.7, and 6.6 vs. 3.9, respectively). This simply reflects the fact that the non-completions are cases that are harder to track. As we did not set any limit on the numbers of calls and contacts we made to track them down, their averages are inevitably higher.